4190.568: Advanced Operating Systems

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Systems Software & Architecture Lab.

Seoul National University

Fall 2022

Course Information

- Schedule
  - 11:00 – 12:15 (Tuesday & Thursday)
  - Engineering Bldg. #301-101
 - 3 credits
  - Official language: English

- TA: TBD

- Course homepage:
  http://csl.snu.ac.kr/courses/4190.568/2022-2/

- Lecture slides will be uploaded in the course homepage before the class

About Me

- Jin-Soo Kim (김진수)
  - Professor @ CSE Dept.
  - Systems Software & Architecture Laboratory
  - Operating systems, storage systems, parallel and distributed computing, embedded systems, …

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- Tel: 02-880-7302

- Office: Engineering Bldg. #301-504

- The best way to contact me is by email
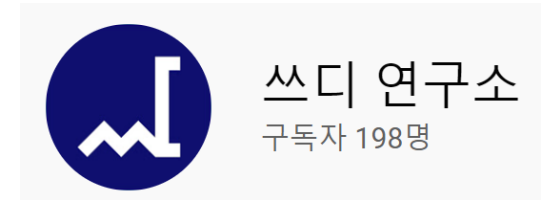
Prerequisites

- **Prerequisites**
  - M1522.000800 Undergraduate Systems Programming or equivalent
  - 4190.307 Undergraduate Operating Systems or equivalent
  - 4190.308 Undergraduate Computer Architecture or equivalent

- **We will review some of fundamental operating system concepts to awaken the force within you**

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Course Plan

- Lectures
  - Advanced topics on operating systems
  - Linux case study
- Invited talks
- Reading assignments
  - You should read them BEFORE the class
  - ~~There will be quizzes~~
- ~~Paper presentation~~
- Assignments & Term project
- Exams (three times)

Topics Planned

- Introduction to computer systems research
- Introduction to operating systems
- Storage
- File systems
- SSDs

- Processes and threads
- CPU scheduling
- ~~Synchronization~~
- Virtual memory
- Linux memory management
- Virtual machines
- OS structure and design

Class Materials

- Quality research papers from major conferences will be used:
  - SOSP (ACM Symposium on Operating Systems Principles)
  - OSDI (USENIX Symposium on Operating Systems Design and Implementation)
  - ASPLOS (ACM Conference on Architectural Support for Programming Languages and Operating Systems)
  - USENIX ATC (USENIX Annual Technical Conference)
  - FAST (USENIX Conference on File and Storage Technologies)
  - EuroSys (ACM European Systems Conference)
  - NSDI (USENIX Symposium on Networked Systems Design and Implementation)
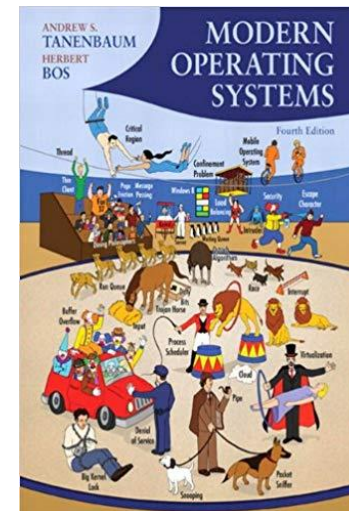 - …

References

- **Operating Systems: Three Easy Pieces**
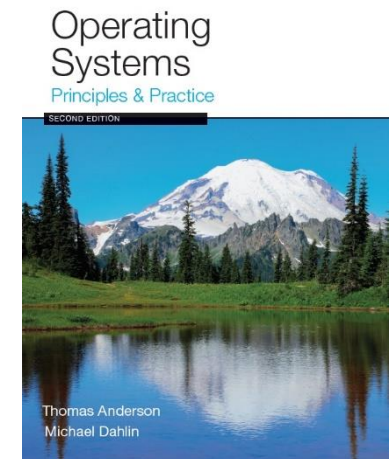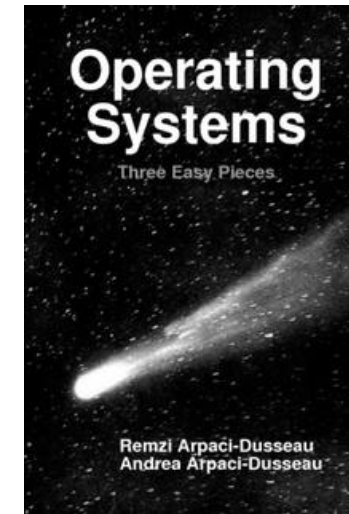 - By Remzi & Andrea Arpaci-Dusseau
  - Freely available at http://ostep.org

- **Operating Systems: Principles and Practice**
  - By Tom Anderson & Michael Dahlin
  - 2nd Edition, Recursive Books, 2014

- **Modern Operating Systems**
  - By Andrew Tanenbaum & Herbert Bos
  - 4th Edition, Pearson Education, 2015

Reading Assignments

- Critical reading of technical papers is a must skill to have for your research

- The reading list will be posted in the course home page

Reading List

Historical Perspective

- (H1) ⭐ D. Ritchie and K. Thompson, "The UNIX Time-Sharing System," CACM, 1974. (The SIGOPS Hall of Fame Award '05)

Computer Systems Research

- (I1) ⭐ Butler W. Lampson, "Hints for Computer System Design," SOSP, 1983. (The SIGOPS Hall of Fame Award '05)

- (I2) Roy Levin and David D. Redell, "An Evaluation of the Ninth SOSP Submissions or How (and How Not) to Write a Good Systems Paper," ACM Operating Systems Review, 1983.

- (I3) Aaron B. Brown, Anupam Chanda, Rik Farrow, Alexandra Fedorova, Petros Maniatis, and Michael L. Scott, "The Many Faces of Systems Research - And How to Evaluate Them," HotOS, 2005.

Assignments

- There will be several assignments for your hands-on experience on Linux

- Reference Linux kernel: 5.15.63 (longterm maintenance kernel)
  - Download it from https://kernel.org/pub/linux/kernel/v5.x/linux-5.15.63.tar.gz

The Linux Kernel Archives

	About	Contact us	FAQ	Releases	Signatures	Site news				
mainline:	6.0-rc3		2022-08-28	[tarball]		[patch]	[inc. patch]	[view diff]	[browse]	
stable:	5.19.5		2022-08-29	[tarball]	[pgp]	[patch]	[inc. patch]	[view diff]	[browse]	[changelog]
stable:	5.18.19 [EOL]		2022-08-21	[tarball]	[pgp]	[patch]	[inc. patch]	[view diff]	[browse]	[changelog]
longterm:	5.15.63		2022-08-25	[tarball]	[pgp]	[patch]	[inc. patch]	[view diff]	[browse]	[changelog]
longterm:	5.10.139		2022-08-29	[tarball]	[pgp]	[patch]	[inc. patch]	[view diff]	[browse]	[changelog]
longterm:	5.4.211		2022-08-25	[tarball]	[pgp]	[patch]	[inc. patch]	[view diff]	[browse]	[changelog]
longterm:	4.19.256		2022-08-25	[tarball]	[pgp]	[patch]	[inc. patch]	[view diff]	[browse]	[changelog]
longterm:	4.14.291		2022-08-25	[tarball]	[pgp]	[patch]	[inc. patch]	[view diff]	[browse]	[changelog]
longterm:	4.9.326		2022-08-25	[tarball]	[pgp]	[patch]	[inc. patch]	[view diff]	[browse]	[changelog]
linux-next:	next-20220830		2022-08-30						[browse]	

Projects: Basic Policies

- Term projects should be done in teams of three students

- Each project should be completed within this semester with some tangible results
  - New ideas without any evaluation will not be considered for grading, no matter how novel they are

- Project topics need to be related to operating systems (especially to storage and file systems), and must be explicitly okay'd by the instructor

Projects: Possible Topics

- Find a problem in Linux and improve it

- Characterize applications' behavior
  - Scheduling behavior, memory access patterns, storage access patterns, etc.
  - What should be changed to accommodate emerging devices/applications/services?

- Verify whether a certain Linux policy works well under synthetic and real-world workloads
  - e.g., The Linux scheduler: a decade of wasted cores (EuroSys '16)
  - Memory/file system anti-fragmentation policy, hugepage support, etc.

- Find scalability issues in the Linux kernel
  - e.g., Understanding manycore scalability of file systems (ATC '16)

Projects: Possible Topics (cont'd)

- Find bugs in the Linux kernel
  - e.g., Finding crash-consistency bugs with bounded black-box crash testing (OSDI '18)
  - e.g., Can applications recover from fsync failures? (ATC '20)
- Analyze the evolution of a Linux subsystem
  - e.g., A study of Linux file system evolution (FAST '13)
  - e.g., An analysis of performance evolution of Linux's core operations (SOSP '19)
- Reproduce the results from other papers on your platform and investigate a way to improve it
- Code-level analysis on a particular Linux subsystem
  - e.g., Memory management, File system, Synchronization, NUMA support, …

Projects: Past Topics

- Fall 2021
  - http://csl.snu.ac.kr/courses/4190.568/2021-2/#projects

- Fall 2020
  - http://csl.snu.ac.kr/courses/4190.568/2020-2/#projects

- Spring 2019
  - http://csl.snu.ac.kr/courses/4190.568/2019-1/#conf

Projects: Get Some Idea Here, Too!

Projects: Proposal

- Due: October 21st (tentative)

- Format: 1 page, free writing

- Project proposal should include the followings:
  - The motivation and the goal of your work
  - The problem you would like to solve (define clearly)
  - Brief summary of related work
  - Your ideas to solve the problem
  - Research plan for the project

- Project proposals will be reviewed by the instructor

Projects: Mini Conference & Term Paper

- We will have a mini conference at the end of this semester

- Each project team should give a formal presentation

- On June 15th (tentative)

- You are expected to write up a term paper

- Due: December 18th (tentative)

- In ACM/IEEE conference proceedings format (two columns)

- Up to 6-page long in English

Projects: Evaluation

■ Your term paper will be evaluated using the following criteria:

1. Brightness: on your motivation and idea
2. Comprehensiveness: on the survey of existing work
3. Soundness: on your methodology
4. Impressiveness: on your results
5. Your time and efforts spent on this project

Grading Policy

- Assignments: 5%
- Exams: 65%
  - Exam 1:   20%
  - Exam 2:   20%
  - Final exam: 25%
- Term project: 30%

- If your total exam score is below the threshold (i.e., 30/100), you won't get the A or B grade
- *Subject to change*

Take-Home Exam

- Time: 6:00PM ~ 11:55PM, September 2nd (Fri)

- The purpose of this exam is to let you review undergraduate OS materials

- Questions will be posted in the course home page (via Google Form)

- You are not expected to write a book or similar. Answer the question concisely.

- This is an exam, not a homework.
  DO NOT SHARE YOUR ANSWER SHEET WITH OTHERS.

- If you are unable to answer the questions properly, please reconsider taking this course

Reading Assignment #1

- Dennis M. Ritchie and Ken Thompson, "The UNIX Time-Sharing System," CACM, 1974

- Due: Before the class on Sep. 8th